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*THE SCIENCES OF THE IDEAL.**

I SHALL not attempt, in this address, either to justify or to criticize the name, normative science, under which the doctrines which constitute this division are grouped. It is enough for my purpose to recognize at the outset that I am required, by the plans of this congress, to explain what scientific interests seem to me to be common to the work of the philosophers and of the mathematicians. The task is one which makes severe demands upon the indulgence of the listener, and upon the expository powers of the speaker, but it is a task for which the present age has well prepared the way. The spirit which Descartes and Leibniz illustrated seems likely soon to become, in a new and higher sense, prominent in science. The mathematicians are becoming more and more philosophical. The philosophers, in the near future, will become, I believe, more and more mathematical. It is my office to indicate, as well as the brief time and my poor powers may permit, why this ought to be so.

To this end I shall first point out what is that most general community of interest which unites all the sciences that belong to our division. Then I shall indicate what type of recent and special scientific work most obviously bears upon the tasks of all of us alike. Thirdly, I shall state some results and problems to which this type of scientific work has given rise, and shall try to show what promise we have of an early increase of insight regarding our common interests.

I.

The most general community of interest which unites the various scientific activities

* Address for the St. Louis Congress of Arts and Science, before the Division of Normative Science.

that belong to our division is this: We are all concerned with what may be called ideal truth, as distinct from physical truth. Some of us also have a strong interest in physical truth; but none of us lack a notable and scientific concern for the realm of ideas, viewed as ideas.

Let me explain what I mean by these terms. Whoever studies physical truth (taking that term in its most general sense) seeks to observe, to collate and, in the end, to control, facts which he regards as external to his own thought. But instead of thus looking mainly without, it is possible for a man chiefly to take account, let us say, of the consequences of his own hypothetical assumptions—assumptions which may possess but a very remote relation to the physical world. Or again, it is possible for such a student to be mainly devoted to reflecting upon the formal validity of his own inferences, or upon the meaning of his own presuppositions, or upon the value and the interrelation of human ideals. Any such scientific work, reflective, considerate principally of the thinker's own constructions and purposes, or of the constructions and purposes of humanity in general, is a pursuit of ideal truth. The searcher who is mainly devoted to the inquiry into what he regards as external facts, is indeed active; but his activity is molded by an order of existence which he conceives as complete apart from his activity. He is thoughtful; but a power not himself assigns to him the problems about which he thinks. He is guided by ideals; but his principal ideal takes the form of an acceptance of the world as it is, independently of his ideals. His dealings are with nature. His aim is the conquest of a foreign realm. But the student of what may be called, in general terms, ideal truth, while he is devoted as his fellow, the observer of outer nature, to the general purpose of being faithful to the verity as he finds it, is still aware that his own way of finding, or his own creative activity as an inventor of hypotheses, or his own powers of inference, or his conscious ideals, constitute in the main the object into which he is inquiring, and so form an essential aspect of the sort of verity which he is endeavoring to discover. The guide, then, of such a student is, in a peculiar sense, his own reason. His goal is the comprehension of his own meaning, the conscious and thoughtful conquest of himself. His great enemy is not the mystery of outer nature, but the imperfection of his reflective powers. He is, indeed, as unwilling as is any scientific worker to trust his private caprices. He feels as little as does the observer of outer facts, that he is merely noting down, as they pass, the chance products of his arbitrary fantasy. For him, as for any scientific student, truth is indeed objective; and the standards to which he conforms are eternal. But his method is that of an inner considerateness rather than of a curiosity about external phenomena. His objective world is at the same time an essentially ideal world, and the eternal verity in whose light he seeks to live has, throughout his undertakings, a peculiarly intimate relation to the purposes of his own constructive will.

One may then sum up the difference of attitude which is here in question by saying that, while the student of outer nature is explicitly conforming his plans of action, his ideas, his ideals, to an order of truth which he takes to be foreign to himself—the student of the other sort of truth, here especially in question, is attempting to understand his own plans of action, that is, to develop his ideas, or to define his ideals, or else to do both these things.

Now it is not hard to see that this search for some sort of ideal truth is indeed characteristic of every one of the investigations which have been grouped together in our division of the normative sciences. Pure

mathematics shares in common with philosophy this type of scientific interest in ideal, as distinct from physical or phenomenal truth. There is, to be sure, a marked contrast between the ways in which the mathematician and the philosopher approach, select and elaborate their respective sorts of problems. But there is also a close relation between the two types of investigation in question. Let us next consider both the contrast and the analogy in some of their other most general features.

Pure mathematics is concerned with the investigation of the logical consequences of certain exactly statable postulates or hypotheses—such, for instance, as the postulates upon which arithmetic and analysis are founded, or such as the postulates that lie at the basis of any type of geometry. For the pure mathematician, the truth of these hypotheses or postulates depends, not upon the fact that physical nature contains phenomena answering to the postulates, but solely upon the fact that the mathematician is able, with rational consistency, to state these assumed first principles, and to develop their consequences. Dedekind, in his famous essay, 'Was Sind und Was Sollen die Zahlen,' called the whole numbers 'freie Schöpfungen des Menschlichen Geistes'; and, in fact, we need not enter into any discussion of the psychology of our number concept in order to be able to assert that, however we men first came by our conception of the whole numbers, for the mathematician the theory of numerical truth must appear simply as the logical development of the consequences of a few fundamental first principles, such as those which Dedekind himself, or Peano, or other recent writers upon this topic, have, in various forms, stated. A similar formal freedom marks the development of any other theory in the realm of pure mathematics. Pure geometry, from the modern point of view, is neither a doctrine forced upon the human mind by the constitution of any primal form of intuition, nor yet a branch of physical science, limited to describing the spatial arrangement of phenomena in the external world. Pure geometry is the theory of the consequences of certain postulates which the geometer is at liberty consistently to make; so that there are as many types of geometry as there are consistent systems of postulates of that generic type of which the geometer takes account. As is also now well known, it has long been impossible to define pure mathematics as the science of quantity, or to limit the range of the exactly statable hypotheses or postulates with which the mathematician deals to the world of those objects which, ideally speaking, can be viewed as measurable. For the ideally defined measurable objects are by no means the only ones whose properties can be stated in the form of exact postulates or hypotheses; and the possible range of pure mathematics, if taken in the abstract, and viewed apart from any question as to the value of given lines of research, appears to be identical with the whole realm of the consequences of exactly statable ideal hypotheses of every type.

One limitation must, however, be mentioned, to which the assertion just made is, in practise, obviously subject. And this is, indeed, a momentous limitation. The exactly stated ideal hypotheses whose consequences the mathematician develops must possess, as is sometimes said, sufficient intrinsic importance to be worthy of scientific treatment. They must not be trivial hypotheses. The mathematician is not, like the solver of chess problems, merely displaying his skill in dealing with the arbitrary fictions of an ideal game. His truth is, indeed, ideal; his world is, indeed, treated by his science as if this world were the creation of his postulates a 'freie Schöpfung.' But he does not thus create for

mere sport. On the contrary, he reports a significant order of truth. As a fact, the ideal systems of the pure mathematician are customarily defined with an obvious, even though often highly abstract and remote, relation to the structure of our ordinary empirical world. Thus the various algebras which have been actually developed have, in the main, definite relations to the structure of the space world of our physical experience. The different systems of ideal geometry, even in all their ideality, still cluster, so to speak, about the suggestions which our daily experience of space and of matter give us. Yet I suppose that no mathematician would be disposed, at the present time, to accept any brief definition of the degree of closeness or remoteness of relation to ordinary experience which shall serve to distinguish a trivial from a genuinely significant branch of mathematical theory. In general a mathematician who is devoted to the theory of functions, or to group theory, appears to spend little time in attempting to show why the development of the consequences of his postulates is a significant enterprise. The concrete mathematical interest of his inquiry sustains him in his labors, and wins for him the sympathy of his fellows. To the questions, 'Why consider the ideal structure of just this system of object at all?' 'Why study various sorts of numbers, or the properties of functions, or of groups, or the system of points in projective geometry?' —the pure mathematician in general, cares to reply only, that the topic of his special investigation appears to him to possess sufficient mathematical interest. The freedom of his science thus justifies his enterprise. Yet, as I just pointed out, this freedom is never mere caprice. This ideal interest is not without a general relation to the concerns even of common sense. In brief, as it seems at once fair to say, the pure mathematician is working under the influence of more or less clearly conscious philosophical motives. He does not usually attempt to define what distinguishes a significant from a trivial system of postulates, or what constitutes a problem worth attacking from the point of view of pure mathematics. But he practically recognizes such a distinction between the trivial and the significant regions of the world of ideal truth, and since philosophy is concerned with the significance of ideas, this recognition brings the mathematician near in spirit to the philosopher.

Such, then, is the position of the pure mathematician. What, by way of contrast, is that of the philosopher? We may reply that to state the formal consequences of exact assumptions is one thing; to reflect upon the mutual relations, and the whole significance of such assumptions, does indeed involve other interests; and these other interests are the ones which directly carry us over to the realm of philosophy. If the theory of numbers belongs to pure mathematics, the study of the place of the number concept in the system of human ideas belongs to philosophy. Like the mathematician, the philosopher deals directly with a realm of ideal truth. But to unify our knowledge, to comprehend its sources, its meaning, and its relations to the whole of human life, these aims constitute the proper goal of the philosopher. In order, however, to accomplish his aims, the philosopher must, indeed, take account of the results of the special physical science; but he must also turn from the world of outer phenomena to an ideal world. For the unity of things is never, for us mortals, anything that we find given in our experience. You can not see the unity of knowledge; you can not describe it as a phenomenon. It is for us now, an ideal. And precisely so, the meaning of things, the relation of knowledge to life, the significance of our ideals, their bearing upon one

another—these are never, for us men, phenomenally present data. Hence the philosopher, however much he ought, as indeed he ought, to take account of phenomena, and of the results of the special physical sciences, is quite as deeply interested in his own way, as the mathematician is interested in his way, in the consideration of an ideal realm. Only, unlike the mathematician, the philosopher does not first abstract from the empirical suggestions upon which his exact ideas are actually based, and then content himself merely with developing the logical consequences of these ideas. On the contrary, his main interest is not in any idea or fact in so far as it is viewed by itself, but rather in the interrelations, in the common significance, in the unity, of all fundamental ideas, and in their relations both to the phenomenal facts and to life! On the whole, he, therefore, neither consents, like the student of a special science of experience, to seek his freedom solely through conformity to the phenomena which are to be described; nor is he content, like the pure mathematician, to win his truth solely through the exact definition of the formal consequences of his freely defined hypotheses. He is making an effort to discover the sense and the unity of the business of his own life.

It is no part of my purpose to attempt to show here how this general philosophical interest differentiates into the various interests of metaphysics, of the philosophy of religion, of ethics, of esthetics, of logic. Enough—I have tried to illustrate how, while both the philosopher and the mathematician have an interest in the meaning of ideas rather than in the description of external facts, still there is a contrast which does, indeed, keep their work in large measure asunder, viz., the contrast due to the fact that the mathematician is directly concerned with developing the consequences of certain freely assumed systems of postulates or hypotheses; while the philosopher is interested in the significance, in the unity and in the relation to life, of all the fundamental ideals and postulates of the human mind.

Yet not even thus do we sufficiently state how closely related the two tasks are. For this very contrast, as we have also suggested, is, even within its own limits, no final or perfectly sharp contrast. There is a deep analogy between the two tasks. For the mathematician, as we have just seen, is not evenly interested in developing the consequences of any and every system of freely assumed postulates. He is no mere solver of arbitrary ideal puzzles in general. His systems of postulates are so chosen as to be not trivial, but significant. They are, therefore, in fact, but abstractly defined aspects of the very system of eternal truth whose expression is the universe. In this sense the mathematician is as genuinely interested as is the philosopher in the significant use of his scientific freedom. On the other hand, the philosopher, in reflecting upon the significance and the unity of fundamental ideas, can only do so with success in case he makes due inquiry into the logical consequences of given ideas. And this he can accomplish only if, upon occasion, he employs the exact methods of the mathematician, and develops his systems of ideal truth with the precision of which only mathematical research is capable. As a fact, then, the mathematician and the philosopher deal with ideal truth in ways which are not only contrasted, but profoundly interconnected. The mathematician, in so far as he consciously distinguishes significant from trivial problems, and ideal systems, is a philosopher. The philosopher, in so far as he seeks exactness of logical method, in his reflection, must meanwhile aim to be, within his own limits, a mathematician. He, indeed, will not in future, like Spinoza,

seek to reduce philosophy to the mere development, in mathematical form, of the consequences of certain arbitrary hypotheses. He will distinguish between a reflection upon the unity of the system of truth and an abstract development of this or that selected aspect of the system. But he will see more and more that, in so far as he undertakes to be exact, he must aim to become, in his own way, and with due regard to his own purposes, mathematical; and thus the union of mathematical and philosophical inquiries, in the future, will tend to become closer and closer.

II.

So far, then, I have dwelt upon extremely general considerations relating to the unity and the contrast of mathematical and philosophical inquiries. I can well conceive, however, that the individual worker in any one of the numerous branches of investigation which are represented by the body of students whom I am privileged to address, may at this point mentally interpose the objection that all these considerations are, indeed, far too general to be of practical interest to any of us. Of course, all we who study these so-called normative sciences are, indeed, interested in ideas, for their own sakes—in ideas so distinct from, although of course also somehow related to, phenomena. Of course some of us are rather devoted to the development of the consequences of exactly stated ideal hypotheses, and others to reflecting as we can upon what certain ideas and ideals are good for, and upon what the unity is of all ideas and ideals. Of course if we are wise enough to do so, we have much to learn from one another. But, you will say, the assertion of all these things is a commonplace. The expression of the desire for further mutual cooperation is a pious wish. You will insist upon asking further: "Is there just now any concrete instance in a modern type of research which furnishes results such as are of interest to all of us? Are we actually doing any productive work in common? Are the philosophers contributing anything to human knowledge which has a genuine bearing upon the interests of mathematical science? Are the mathematicians contributing anything to philosophy?"

These questions are perfectly fair. Moreover, as it happens, they can be distinctly answered in the affirmative. The present age is one of a rapid advance in the actual unification of the fields of investigation which are included within the scope of this present division. What little time remains to me must be devoted to indicating, as well as I can, in what sense this is true. I shall have still to deal in very broad generalities. I shall try to make these generalities definite enough to be not wholly unfruitful.

We have already emphasized one question which may be said to interest, in a very direct way, both the mathematician and the philosopher. The ideal postulates, whose consequences mathematical science undertakes to develop, must be, we have said, significant postulates, involving ideas whose exact definition and exposition repay the labor of scientific scrutiny. Number, space, continuity, functional correspondence or dependence, group-structure—these are examples of such significant ideas; the postulates or ideal assumptions upon which the theory of such ideas depends are significant postulates, and are not the mere conventions of an arbitrary game. But now what constitutes the significance of an idea, or of an abstract mathematical theory? What gives an idea a worthy place in the whole scheme of human ideas? Is it the possibility of finding a physical application for a mathematical theory which for us decides what is the value of the theory? No, the theory of functions, the theory of numbers, group theory, have

a significance which no mathematician would consent to measure in terms of the present applicability or non-applicability of these theories in physical science? In vain, then, does one attempt to use the test of applied mathematics as the main criticism of the value of a theory of pure mathematics. The value of an idea, for the sciences which constitute our division, is dependent upon the place which this idea occupies in the whole organized scheme or system of human ideas. The idea of number, for instance, familiar as its applications are, does not derive its main value from the fact that eggs and dollars and star-clusters can be counted, but rather from the fact that the idea of numbers has those relations to other fundamental ideas which recent logical theory has made prominent—relations, for instance, to the concept of order, to the theory of classes or collections of objects viewed in general, and to the metaphysical concept of the self. Relations of this sort, which the discussions of the number concept by Dedekind, Cantor, Peano and Russell have recently brought to light—such relations, I say, constitute what truly justified Gauss in calling the theory of numbers a 'divine science.' As against such deeper relations, the countless applications of the number concept in ordinary life, and in science, are, from the truly philosophical point of view, of comparatively small moment. What we want, in the work of our division of the sciences, is to bring to light the unity of truth, either, as in mathematics, by developing systems of truth which are significant by virtue of their actual relations to this unity, or, as in philosophy, by explicitly seeking the central idea about which all the many ideas cluster.

Now, an ancient and fundamental problem for the philosophers is that which has been called the problem of the categories. This problem of the categories is simply the more formal aspect of the whole philosophical problem just defined. The philosopher aims to comprehend the unity of the system of human ideas and ideals. Well, then, what are the primal ideas? Upon what group of concepts do the other concepts of human science logically depend? About what central interests is the system of human ideals clustered? In ancient thought Aristotle already approached this problem in one way. Kant, in the eighteenth century, dealt with it in another. We students of philosophy are accustomed to regret what we call the excessive formalism of Kant, to lament that Kant was so much the slave of his own relatively superficial and accidental table of categories, and that he made the treatment of every sort of philosophical problem turn upon his own schematism. Yet we can not doubt that Kant was right in maintaining that philosophy needs, for the successful development of every one of its departments, a well-devised and substantially complete system of categories. Our objection to Kant's over-confidence in the virtues of his own schematism is due to the fact that we do not now accept his table of categories as an adequate view of the fundamental concepts. The efforts of philosophers since Kant have been repeatedly devoted to the task of replacing his scheme of categories by a more adequate one. I am far from regarding these purely philosophical efforts made since Kant as fruitless, but they have remained, so far, very incomplete, and they have been held back from their due fulness of success by the lack of a sufficiently careful survey and analysis of the processes of thought as these have come to be embodied in the living sciences. Such concepts as number, quantity, space, time, cause, continuity, have been dealt with by the pure philosophers far too summarily and superficially. A more thoroughgoing analysis has been needed.

But now, in comparatively recent times, there has developed a region of inquiry which one may call by the general name of modern logic. To the constitution of this new region of inquiry men have principally contributed who began as mathematicians, but who, in the course of their work, have been led to become more and more philosophers. Of late, however, various philosophers, who were originally in no sense mathematicians, becoming aware of the importance of the new type of research, are in their turn attempting both to assimilate and to supplement the undertakings which were begun from the mathematical side. As a result, the logical problem of the categories has to-day become almost equally a problem for the logicians of mathematics and for those students of philosophy who take any serious interest in exactness of method in their own branch of work. The result of this actual cooperation of men from both sides is that, as I think, we are to-day, for the first time, in sight of what is still, as I freely admit, a somewhat distant goal, viz., the relatively complete rational analysis and tabulation of the fundamental categories of human thought. That the student of ethics is as much interested in such an investigation as is the metaphysician, that the philosopher of religion needs a well-completed table of categories quite as much as does the pure logician, every competent student of such topics ought to admit. And that the enterprise in question keenly interests the mathematicians is shown by the prominent part which some of them have taken in the researches in question. Here, then, is the type of recent scientific work whose results most obviously bear upon the tasks of all of us alike.

A catalogue of the names of the workers in this wide field of modern logic would be out of place here. Yet one must, indeed, indicate what lines of research are especially in question. From the purely mathematical side, the investigations of the type to which I now refer may be viewed (somewhat arbitrarily) as beginning with that famous examination into one of the postulates of Euclid's geometry which gave rise to the so-called non-Euclidean geometry. The question here originally at issue was one of a comparatively limited scope, viz., the question whether Euclid's parallel-line postulate was a logical consequence of the other geometrical principles. But the investigation rapidly develops into a general study of the foundations of geometry—a study to which contributions are still almost constantly appearing. Somewhat independently of this line of inquiry there grew up, during the latter half of the nineteenth century, that reexamination of the bases of arithmetic and analysis which is associated with the names of Dedekind, Weierstrass and George Cantor. At the present time, the labors of a number of other inquirers (amongst whom we may mention the school of Peano and Pieri in Italy, and men such as Poincaré and Couturat in France, Hilbert in Germany, Bertram Russell and Whitehead in England and an energetic group of our American mathematicians—men such as Professor Moore, Professor Halsted, Dr. Huntington, Dr. Veblen and a considerable number of others) have been added to the earlier researches. The result is that we have recently come for the first time to be able to see, with some completeness, what the assumed first principles of pure mathematics actually are. As was to be expected, these principles are capable of more than one formulation, according as they are approached from one side or from another. As was also to be expected, the entire edifice of pure mathematics, so far as it has yet been erected, actually rests upon a very few fundamental concepts and postulates, however you may formulate them. What was not observed,

however, by the earlier, and especially by the philosophical, students of the categories, is the form which these postulates tend to assume when they are rigidly analyzed.

This form depends upon the precise definition and classification of certain types of relations. The whole of geometry, for instance, including metrical geometry, can be developed from a set of postulates which demand the existence of points that stand in certain ordinal relationships. The ordinal relationships can be reduced, according as the series of points considered is open or closed, either to the well-known relationship in which three points stand when one is between the other two upon a right line, or else to the ordinal relationship in which four points stand when they are separated by pairs; and these two ordinal relationships, by means of various logical devices, can be regarded as variations of a single fundamental form. Cayley and Klein founded the logical theory of geometry here in question. Russell, and in another way Dr. Veblen, have given it its most recent expressions. In the same way, the theory of whole numbers can be reduced to sets of principles which demand the existence of certain ideal objects in certain simple ordinal relations. Dedekind and Peano have worked out such ordinal theories of the number concept. In another development of the theory of the cardinal whole numbers, which Russell and Whitehead have worked out, ordinal concepts are introduced only secondarily, and the theory depends upon the fundamental relation of the equivalence or non-equivalence of collections of objects. But here also a certain simple type of relation determines the definitions and the development of the whole theory.

Two results follow from such a fashion of logically analyzing the first principles of mathematical science. In the first place, as just pointed out, we learn *how few and simple are the conceptions and postulates* upon which the actual edifice of exact science rests. Pure mathematics, we have said, is free to assume what it chooses. Yet the assumptions whose presence as the foundation principles of the actually existent pure mathematics an exhaustive examination thus reveals, show by their fewness that the ideal freedom of the mathematician to assume and to construct what he pleases, is indeed, in practise, a very decidedly limited freedom. The limitation is, as we have already seen, a limitation which has to do with the essential significance of the fundamental concepts in question. And so the result of this analysis of the bases of the actually developed and significant branches of mathematics, constitutes a sort of empirical revelation of what categories the exact sciences have practically found to be of such significance as to be worthy of exhaustive treatment. Thus the instinctive sense for significant truth which has all along been guiding the development of mathematics, comes at least to a clear and philosophical consciousness. And meanwhile the essential categories of thought are seen in a new light.

The second result still more directly concerns a philosophical logic. It is this: Since the few types of relations which this sort of analysis reveals as the fundamental ones in exact science are of such importance, the logic of the present day is especially required to face the questions: *What is the nature of our concept of relations?* What are the various possible types of relations? Upon what does the variety of these types depend? What unity lies beneath the variety?

As a fact, logic, in its modern forms, viz., first that symbolic logic which Boole first formulated, which Mr. Charles S. Peirce and his pupils have in this country already so highly developed, and which Schroeder in Germany, Peano's school in Italy and

a number of recent English writers, have so effectively furthered—and secondly, the logic of scientific method, which is now so actively pursued, in France, in Germany and in the English-speaking countries—this whole movement in modern logic, as I hold, is rapidly approaching *new solutions of the problem of the fundamental nature and the logic of relations*. The problem is one in which we are all equally interested. To De Morgan in England, in an earlier generation, and, in our time, to Charles Peirce in this country, very important stages in the growth of these problems are due. Russell, in his work on the 'Principles of Mathematics,' has very lately undertaken to sum up the results of the logic of relations, as thus far developed, and to add his own interpretations. Yet I think that Russell has failed to get as near to the foundations of the theory of relations as the present state of the discussion permits. For Russell has failed to take account of what I hold to be the most fundamentally important generalization yet reached in the general theory of relations. This is the generalization set forth as early as 1890, by Mr. A. B. Kempe, of London, in a pair of wonderful, but too much neglected, papers, entitled, respectively, 'The Theory of Mathematical Form,' and 'The Analogy between the Logical Theory of Classes and the Geometrical Theory of Points.' A mere hint first as to the more precise formulation of the problem at issue, and then later as to Kempe's special contribution to that problem, may be in order here, despite the impossibility of any adequate statement.

III.

The two most obviously and universally important kinds of relations known to the exact sciences, as these sciences at present exist, are: (1) The relations of the type of equality or equivalence; and (2) the relations of the type of before and after, or greater and less. The first of these two classes of relations, viz., the class represented, although by no means exhausted, by the various relations actually called, in different branches of science by the one name equality, this class I say, might well be named, as I myself have proposed, the leveling relations. A collection of objects between any two of which some one relation of this type holds, may be said to be a collection whose members, in some defined sense or other, are on the same level. The second of these two classes of relations, viz., those of the type of before and after, or greater and less—this class of relations, I say, consists of what are nowadays often called the serial relations. And a collection of objects such that, if any pair of these objects be chosen, a determinate one of this pair stands to the other one of the same pair in some determinate relation of this second type, and in a relation which remains constant for all the pairs that can be thus formed out of the members of this collection—any such collection, I say, constitutes a one-dimensional open series. Thus, in case of a file of men, if you choose any pair of men belonging to the file, a determinate one of them is, in the file, before the other. In the number series, of any two numbers, a determinate one is greater than the other. Wherever such a state of affairs exists, one has a series.

Now these two classes of relations, the leveling relations and the serial relations, agree with one another, and differ from one another in very momentous ways. They *agree* with one another in that both the leveling and the serial relations are what is technically called *transitive;* that is, both classes conform to what Professor James has called the law of 'skipped intermediaries.' Thus, if A is equal to B, and B is equal to C, it follows that A is equal to C. If A is before B, and B is before C, then A is before C. And this property,

which enables you in your reasonings about these relations to skip middle terms, and so to perform some operation of elimination, is the property which is meant when one calls relations of this type transitive. But, on the other hand, these two classes of relations *differ* from each other in that the leveling relations are, while the serial relations are not, *symmetrical* or reciprocal. Thus, if A is equal to B, B is equal to A. But if X is greater than Y, then Y is not greater than X, but less than X. So the leveling relations are symmetrical transitive relations. But the serial relations are transitive relations which are not symmetrical.

All this is now well known. It is notable, however, that nearly all the processes of our exact sciences, as at present developed, can be said to be essentially such as lead either to the placing of sets or classes of objects on the same level, by means of the use of symmetrical transitive relations, or else to the arranging of objects in orderly rows or series, by means of the use of transitive relations which are not symmetrical. This holds also of all the applications of the exact sciences. Whatever else you do in science (or, for that matter, in art), you always lead, in the end, either to the arranging of objects, or of ideas, or of acts, or of movements, in rows or series, or else to the placing of objects or ideas of some sort on the same level, by virtue of some equivalence, or of some invariant character. Thus numbers, functions, lines in geometry, give you examples of serial relations. Equations in mathematics are classic instances of leveling relations. So, of course, are invariants. Thus, again, the whole modern theory of energy consists of two parts, one of which has to do with levels of energy, in so far as the quantity of energy of a closed system remains invariant through all the transformations of the system, while the other part has to do with the irreversible serial order of the transformations of energy themselves, which follow a set of unsymmetrical relations, in so far as energy tends to fall from higher to lower levels of intensity within the same system.

The entire conceivable universe then, and all of our present exact science, can be viewed, if you choose, as a collection of objects or of ideas that, whatever other types of relations may exist, are at least largely characterized either by the leveling relations, or by the serial relations, or by complexes of both sorts of relations. Here, then, we are plainly dealing with very fundamental categories. The 'between' relations of geometry can of course be defined, if you choose, in terms of transitive relations that are not symmetrical. There are, to be sure, some other relations present in exact science, but the two types, the serial and leveling relations, are especially notable.

So far the modern logicians have for some time been in substantial agreement. Russell's brilliant book is a development of the logic of mathematics very largely in terms of the two types of relations which, in my own way, I have just characterized; although Russell gives due regard, of course, to certain other types of relations.

But hereupon the question arises, 'Are these two types of relations what Russell holds them to be, viz., ultimate and irreducible logical facts, unanalyzable categories—mere data for the thinker? Or can we reduce them still further, and thus simplify yet again our view of the categories?

Here is where Kempe's generalization begins to come into sight. These two categories, in at least one very fundamental realm of exact thought, can be reduced to one. There is, namely, a world of ideal objects which especially interest the logician. It is the world of a *totality of pos-*

sible logical classes, or again, it is the ideal world, equivalent in formal structure to the foregoing, but composed of a *totality of possible statements,* or thirdly, it is the world, equivalent once more, in formal structure, to the foregoing, but consisting of a *totality of possible acts of will,* of possible decisions. When we proceed to consider the relational structure of such a world, taken merely in the abstract as such a structure, a relation comes into sight which at once appears to be peculiarly general in its nature. It is the so-called illative relation, the relation which obtains between two classes when one is subsumed under the other, or between two statements, or two decisions, when one implies or entails the other. This relation is transitive, but may be either symmetrical or not symmetrical; so that, according as it is symmetrical or not, it may be used either to establish levels or to generate series. In the order system of the logician's world, the relational structure is thus, in any case, a highly general and fundamental one.

But this is not all. In this the logician's world of classes, or of statements, or of decisions, there is also another relation observable. This is the relation of exclusion or mutual opposition. This is a purely symmetrical or reciprocal relation. It has two forms—obverse or contradictory opposition, *i. e.,* negation proper, and contrary opposition. But both these forms are purely symmetrical. And by proper devices each of them can be stated in terms of the other, or reduced to the other. And further, as Kempe incidentally shows, and as Mrs. Ladd Franklin has also substantially shown in her important theory of the syllogism, *it is possible to state every proposition, or complex of propositions involving the illative relation, in terms of this purely symmetrical relation of opposition.* Hence, so far as mere relational form is concerned, the illative relation itself may be wholly reduced to the symmetrical relation of opposition. This is our first result as to the relational structure of the realm of pure logic, *i. e.,* the realm of classes, of statements, or of decisions.

It follows that, in describing the logician's world of possible classes or of possible decisions, *all unsymmetrical, and so all serial, relations can be stated solely in terms of symmetrical relations, and can be entirely reduced to such relations.* Moreover, as Kempe has also very prettily shown, the relation of opposition, in its two forms, just mentioned, need not be interpreted as obtaining merely between pairs of objects. It may and does obtain between triads, tetrads, n-ads of logical entities; and so all that is true of the relations of logical classes may consequently be stated merely by ascribing certain perfectly symmetrical and homogeneous predicates to pairs, triads, tetrads, n-ads of logical objects. The essential contrast between symmetrical and unsymmetrical relations thus, in this ideal realm of the logician, simply vanishes. The categories of the logician's world of classes, of statements, or of decisions, are marvelously simple. All the relations present may be viewed as variations of the mere conception of opposition as distinct from non-opposition.

All this holds, of course, so far, merely for the logician's world of classes or of decisions. There, at least, all serial order can actually be derived from wholly symmetrical relations. But Kempe now very beautifully shows (and here lies his great and original contribution to our topic)—he shows, I say, that the ordinal relations of geometry, as well as of the number-system, can all be regarded as indistinguishable from *mere variations of those relations which, in pure logic, one finds to be the symmetrical relations obtaining within pairs or triads of classes or of statements.*

The formal identity of the geometrical relation called 'between' with a purely logical relation which one can define as existing or as not existing amongst the members of a given triad of logical classes, or of logical statements, is shown by Kempe in a fashion that I can not here attempt to expound. But Kempe's result thus enables one, as I believe, to simplify the theory of relations far beyond the point which Russell, in his brilliant book has reached. For Kempe's triadic relation in question can be stated, in what he calls its obverse form, in perfectly symmetrical terms. And he proves very exactly that the resulting logical relation is precisely identical, in all its properties, with the fundamental ordinal relation of geometry.

Thus the order-systems of geometry and analysis appear simply as special cases of the more general order-system of pure logic. The whole, both of analysis and of geometry, can be regarded as a description of certain selected groups of entities, which are chosen, according to special rules, from a single ideal world. This general and inclusive ideal world consists simply of *all the objects which can stand to one another in those symmetrical relations wherein the pure logician finds various statements, or various decisions inevitably standing,* 'Let me,' says in substance Kempe, 'choose from the logician's ideal world of classes or decisions, what entities I will; and I will show you a collection of objects that are in their relational structure, precisely identical with the points of a geometer's space of n dimensions.' In other words, all of the geometer's figures and relations can be precisely pictured by the relational structure of a selected system of classes or of statements, whose relations are wholly and explicitly logical relations, such as opposition, and whose relations may all be regarded, accordingly, as reducible to a single type of purely symmetrical relation.

Thus, for *all* exact science, and not merely for the logician's special realm, the contrast between symmetrical and unsymmetrical relations proves to be, after all, superficial and derived. The purely logical categories, such as opposition, and such as hold within the calculus of statements, are, apparently, the basal categories of all the exact science that has yet been developed. Series and levels are relational structures that, sharply as they are contrasted, can be derived from a single root.

I have restated Kempe's generalization in my own way. I think it the most promising step towards new light as to the categories that we have made for some generations.

In the field of modern logic, I say, then, work is doing which is rapidly tending towards the unification of the tasks of our entire division. For this problem of the categories, in all its abstractness, is still a common problem for all of us. Do you ask, however, what such researches can do to furnish more special aid to the workers in metaphysics, in the philosophy of religion, in ethics, or in esthetics, beyond merely helping towards the formulation of a table of categories—then I reply that we are already not without evidence that such general researches, abstract though they may seem, are bearing fruits which have much more than a merely special interest. Apart from its most general problems, that analysis of mathematical concepts to which I have referred has in any case revealed numerous unexpected connections between departments of thought which had seemed to be very widely sundered. One instance of such a connection I myself have elsewhere discussed at length, in its general metaphysical bearings. I refer to the logical identity which Dedekind first pointed out between the mathematical concept of

the ordinal number of series and the philosophical concept of the formal structure of an ideally completed self. I have maintained that this formal identity throws light upon problems which have as genuine an interest for the student of the philosophy of religion as for the logician of arithmetic. In the same connection it may be remarked that, as Couturat and Russell, amongst other writers, have very clearly and beautifully shown, the argument of the Kantian mathematical antinomies needs to be explicitly and totally revised in the light of Cantor's modern theory of infinite collections. To pass at once to another, and a very different instance: The modern mathematical conceptions of what is called group theory have already received very wide and significant applications, and promise to bring into unity regions of research which, until recently, appeared to have little or nothing to do with one another. Quite lately, however, there are signs that group theory will soon prove to be of importance for the definition of some of the fundamental concepts of that most refractory branch of philosophical inquiry, esthetics. Dr. Emch, in an important paper in the *Monist,* called attention, some time since, to the symmetry groups to which certain esthetically pleasing forms belong, and endeavored to point out the empirical relations between these groups and the esthetic effects in question. The grounds for such a connection between the groups in question and the observed esthetic effects, seemed, in the paper of Dr. Emch to be left largely in the dark. But certain papers recently published in the country by Miss Ethel Puffer, bearing upon the psychology of the beautiful (although the author has approached the subject without being in the least consciously influenced, as I understand, by the conceptions of the mathematical group theory), still actually lead, if I correctly grasp the writer's meaning, to the doctrine that the esthetic object, viewed as a psychological whole, must possess a structure closely, if not precisely, equivalent to the ideal structure of what the mathematician calls a group. I myself have no authority regarding esthetic concepts, and speak subject to correction. But the unexpected, and in case of Miss Puffer's research, quite unintended, appearance of group theory in recent esthetic analysis is to me an impressive instance of the use of relatively new mathematical conceptions in philosophical regions which *seem,* at first sight, very remote from mathematics.

That both the group concept and the concept of the self just suggested are sure to have also a wide application in the ethics of the future, I am myself well convinced. In fact, no branch of philosophy is without close relations to all such studies of fundamental categories.

These are but hints and examples. They suffice, I hope, to show that the workers in this division have deep common interests, and will do well, in future, to study the arts of cooperation, and to regard one another's progress with a watchful and cordial sympathy. In a word: Our common problem is the theory of the categories. That problem can be solved only by the cooperation of the mathematicians and of the philosophers.

Josiah Royce.
Harvard University.

SCIENTIFIC BOOKS.

The Harriman Alaska Expedition. Vol. X. Crustaceans. By Mary J. Rathbun, Harriet Richardson, S. J. Holmes and Leon J. Cole. New York, Doubleday, Page and Co. 1904. Pp. x + 337. 8vo; with xxvi plates and 128 figures in the text.

In working out the shrimps of the Harriman expedition Miss Rathbun was obliged to review the entire material of that group from northwest America which had accumulated in the National Museum and, in addition to the

results of that study, has provided a check list of the Decapoda inhabiting the coast from southern California northward. An effort has been made to figure all the less known species. When it is considered that the basis of this study includes the rich collections of the U. S. Fish Commission from Lower California to the Arctic; the extensive explorations on the Alaskan coast and the Aleutian islands made by Dall; and the fruit of lesser researches by a large number of collectors and students, including Stimpson, Lockington and Holmes—in all some 50,000 specimens—it can be realized how extensive and valuable an addition to our knowledge of the Crustacea of the north Pacific is embraced in Miss Rathbun's painstaking memoir.

The decapod fauna of the north Pacific is rich in individuals if not in species. Certain types were found in especial profusion, such as the shrimps belonging to the Pandalidæ, Hippolytidæ and Crangonidæ, the hermit crabs, the maioid spider crabs and the Lithodidæ or anomouran spider crabs. The Pandalidæ take the lead in numbers. The most abundant species are *Pandalus borealis* and a subspecies of the Atlantic *P. montagui*, boreal forms which extend southward from the Arctic into both oceans, but seem to find the most favorable environment in the Pacific.

In number of species the genus *Spirontocaris* of the Hippolytidæ is unsurpassed, being represented in the north Pacific by fifty-one species exhibiting great diversity of form, several of which are also common to the Atlantic. Like *Pandalus*, it is essentially a boreal group. The Crangonidæ also occur in great numbers and include thirty-two different forms, mostly restricted to the Pacific. The hermit crabs are also very abundant and to some extent rather local, occurring in their finest development in a special region, outside of which these species are often rare and stunted.

In their distribution many of the Arctic forms continue southward on either shore to the Kurile Islands, on the one hand, or Puget Sound, etc., on the other. As with the mollusks, fishes and marine mammals, the winter line of floating ice in Bering Sea determines the northern limit of many forms. While many species run without interruption from this limit south to California, the distribution of others indicates the possible division of the fauna geographically into subfaunæ, points of limitation being indicated near Kadiak, Fuca Strait and Monterey, California. Some Bering Sea species occur sporadically in the cold waters of glacier-fed bays in southeastern Alaska, where they are, perhaps, relics of that glacial time when the immediate waters of the whole coast were much colder than at present. A few Japanese species also appear sporadically in analogous latitudes on the American coast, without, so far as known, inhabiting the intervening region. The archibenthal species, as was to be expected, have a greater range than those restricted to the more variable environment of the shallow waters of the coast.

The memoir is abundantly illustrated and will be of permanent value to all interested in the natural history of the Crustacea.

Dr. Richardson's paper includes a list of the isopods collected by the Harriman expedition, together with others obtained on the Californian coast by Professor W. E. Ritter. In all, twenty-one species are enumerated, of which five are regarded as new, while the doubtful *Idotea gracillima* is reidentified, figured and redescribed. A *Munna* was taken at the Pribiloff Islands in a state too mutilated to describe, but the presence of a species of this family heretofore unknown from the Pacific coast is a fact of interest.

Dr. Holmes describes six new amphipods and enumerates sixteen others from the collections of the Harriman expedition, most of which are well illustrated, but it is probable that a complete collection would considerably increase this number, these animals being remarkably abundant on the Alaskan coast.

The remainder of the volume is devoted to a report on the littoral Pycnogonidæ of the west coast of North America by Mr. Cole. This covers a field almost entirely new to the literature. Twelve species are described and profusely illustrated, of which one is circumpolar and two others are probably evolved from circumpolar types. The list simply in-

dicates a beginning, as there is an almost unexplored gap between northern California and Prince William Sound, while among the Aleutian Islands pycnogonids are rather abundant, and would probably, on thorough exploration, add considerably to the number of four species now known from that region.

The book concludes with an excellent index and well sustains the high reputation which the earlier volumes of this important series have maintained.

W. H. DALL.

SMITHSONIAN INSTITUTION.

Chemie der Eiweisskörper. Von Dr. OTTO COHNHEIM, A. o. Professor an der Universität Heidelberg. Zweite vollständig neu bearbeitete Auflage. Braunschweig, F. Vieweg und Sohn. 1904.

The first edition of Cohnheim's 'Chemie der Eiweisskörper,' published in 1900, speedily gained a wide circulation among physiological chemists and won for itself a place as a most useful book of reference. No other comprehensive and satisfactory compilation of the literature on proteids had been attempted since Drechsel's article in Ladenburg's 'Handwörterbuch,' published in 1885. The appearance of a new edition by Cohnheim, so completely revised in some parts that it almost deserves to be called a new book, testifies the popularity which the work has enjoyed and above all the rapid progress which the study of proteid chemistry has made in this brief period of four years. An era of classification in which new proteids were isolated and their physical and chemical properties investigated, has been followed by renewed interest in the chemical structure of the albuminous substances. The recent fruitful researches of Emil Fischer, Kossel and others bear witness to the advances which improved methods of study can inaugurate. Accordingly, we find in the new volume an entire chapter devoted to the chemical constitution of the proteids. This, as well as other parts of the book, is characterized not only by the completeness and accuracy of the list of references to the literature, including the earlier pioneer work, but also by the exercise of critique in the presentation of such detailed data. It is this selective and unbiased treatment which makes a compilation readable.

Without attempting any detailed review, it may be of interest to refer to some of the more noteworthy changes or innovations in the present edition. The molecular structure characteristic of the proteids and serving to define them is summarized in the following words:

Die wichtigste Gruppierung ist nun sicher die oben besprochene Säureamidbindung der α-Amidosäuren, und man kann daraufhin Körper wie das Glycylglycin und seine Homologen als die einfachste Eiweisskörper bezeichnen. Richtiger ist es aber wohl, Kossel zu folgen, und auch die zweite Verbindungsform, wie sie im Arginin vorliegt, als notwendig für den Eiweissbegriff anzusehen. Danach hat man als Eiweisskörper Säureamide aus α-Amidosäuren zu bezeichnen, von denen eine das Arginin ist.

Unter diese Definition fallen zweifellos alle Peptone und auch die komplizierteren Peptide, ebenso die Protamine, deren Abtrennung von den Eiweisskörpern bei den breiten chemischen und genetischen Übergangen zwischen ihnen und den anderen Eiweisskörpern durchaus willkurlich erscheint. Die von Löw und Hofmeister versuchte Heranziehung des physiologischen Elementes hat bei einer chemischen Definition Bedenken und ist unzulässig, seit es wahrscheinlich geworden ist, dass der Tierkörper sein Eiweiss aus allen stickstoffhaltigen Verbindungen aufbauen kann, die für seine Fermente zugänglich sind (p. 71).

The discussion of the physical and physicochemical properties of proteids has been modified to conform with changing ideas. This is especially evident in Chapter V. in the treatment of the salt-like compounds of the proteids. The twofold behavior of the latter towards acids and bases, assigned in the earlier edition to their character as pseudo-acid and pseudo-base (Hantzsch), has given way to a somewhat different interpretation. The unique combining properties of the proteids are now attributed by the author to the amido-acid complexes which form the molecule, since simple amido-acids are known to show precisely similar reactions. In the classification of the proteids no notable change is introduced. Casein is still referred to under the most unsuitable designation of nucleoalbumin, not, however, without at length indicating its specific character as a phosphorus-containing

compound (phosphorhaltiges Eiweiss). The vegetable proteids have not yet received the attention which, in the reviewer's opinion, they deserve. The crystallized vegetable proteids are dismissed with a few words (p. 149) and without any adequate references to the methods of obtaining them, although their preparation has already assumed commercial proportions; the crystallization of egg- and serum-albumin, on the other hand, is carefully considered. It must be said to the credit of Professor Cohnheim that he has, in contrast to most continental writers, shown appreciation of the important work by American investigators in the domain of the vegetable proteids in the present edition.

The greatly enlarged chapter (II.) on cleavage products, beginning with a brief historical review, is excellent in every respect and ought to be warmly welcomed for its exhaustive reference list. The compounds obtained by the action of acids or digestive enzymes are very properly discussed in a separate group as fundamental (primäre Spaltungsprodukte); and the quantitative relations are compiled so far as known. The existence of diaminoacetic acid (Drechsel) is now rendered doubtful (p. 33). In principle the distinction between anti- and hemi-proteid derivatives is still maintained. The chapter on albumoses and peptones has been adapted to the modified system of analysis and nomenclature introduced by the Hofmeister school, the so-called peptids and plasteins also being added. A brief résumé of the behavior of proteids towards the aniline dyes (p. 114) will interest histologists.

The special part of the book, dealing with the individual proteids, is more encyclopædic in character and the innovations are naturally less conspicuous. One receives everywhere an impression of first-hand acquaintance with the literature and must admire the industry and good judgment of the author. Finally, even the most casual examination of this work of three hundred pages can not fail to impress the reader with the growing importance and interest which the study of the proteids is attaining in biology. Lafayette B. Mendel.

Sheffield Scientific School,
Yale University.

SCIENTIFIC JOURNALS AND ARTICLES.

The *American Journal of Science* for October contains the following articles:

'New Devonian Formation in Colorado': W. Cross.

'Upper Devonian Fish Remains from Colorado': C. R. Eastman.

'Fossil Turtles belonging to the Marsh Collection in Yale University Museum': O. P. Hay.

'Air Radiation': C. C. Hutchins and J. C. Pearson.

'Uintacrinus and Hemiaster in the Vancouver Cretaceous': J. F. Whiteaves.

'Separation of the most Volatile Gases from the Air without Liquefaction': J. Dewar.

'Absorption and Thermal Evolution of Gases occluded in Charcoal at Low Temperatures': J. Dewar.

'Studies in the Cyperaceæ': T. Holm.

The Popular Science Monthly for September contains articles on 'The Development of the Theory of Electrolytic Dissociation,' by Svante Arrhenius; the 'Conservation of Human Energy, Preservation of Beauty,' by J. Madison Taylor; 'Art in Industry,' by Frank T. Carlton; 'Some Plants which Entrap Insects,' by Forrest Shreve. This last is very fully illustrated, and calls attention to some of the insects that are adapted for life on or about some insectivorous plants. 'Hebrew, Magyar and Levantine Immigration' is discussed by Allan McLaughlin in an article which is not very encouraging for the United States, in general, and decidedly discouraging to dwellers in New York. Richard L. Sandwick makes a plea for 'More Men (as teachers) in Public Schools,' Charles R. Eastman presents 'A Second Century Criticism of Virgil's Etna' and Robert MacDougall considers 'The Evolution of the Human Hand.' The concluding article, by Simon Newcomb, tells of the International Congress of Arts and Science at St. Louis.

DISCUSSION AND CORRESPONDENCE.

A RECENT PALEONTOLOGICAL INDUCTION.

The concept of arboreal 'horses' already thrice discussed in the current volume of Science, or even concepts of fabled Pegasi, are, from a philosophical standpoint, rational and legitimate products of human conscious-

ness. Nevertheless, the probability of such conceptions having had real counterparts in the material world is absolutely *nil*, so far as experience shows, and for like reason we can ascribe only a mythical existence in times past to warm-blooded reptiles, feathered reptiles, or reptiles possessing so eminently bird-like a characteristic as the *gizzard*.

It is, therefore, surprising to find a writer in Science (No. 501, p. 185) advancing the anomalous conception of reptiles with organs corresponding to the avian gizzard. The solitary fact upon which Mr. Barnum Brown bases his conclusion is the discovery, in a number of instances, of small-sized silicious pebbles in association with plesiosaur skeletons from the western Cretaceous. Certain corollary assumptions, apparently accepted as axiomatic by Mr. Brown, but nevertheless debatable, may be stated as follows:

(1) These 'stomach stones' were contained within the alimentary canal prior to the death of the creatures, and not accidentally deposited upon or with their remains. (2) The stones were intentionally swallowed, and not taken promiscuously with other fare, as might happen in bottom-feeding. (3) They served as a mechanical aid to digestion through the intervention of a supposititious gizzard-like organ. (4) Thin-shelled prey like cephalopods could not have been crushed upon one another without the admixture of a judicious quantity of 'stomach stones.' (5) The non-occurrence of such stones amongst European reptiles proves only that the latter 'had no stomach' for them, not that they were gizzardless. (6) The history of the gizzard (*horresco referens*) shows that it was developed first amongst cold-blooded vertebrates, then lost by them, and afterwards independently acquired by birds. Incidentally it appears that plesiosaurs possessed the most highly specialized digestive apparatus known amongst reptiles, ancient or modern.

For our part, begging pardon of Mr. Brown, we are willing to consign to birds the exclusive enjoyment of gizzards and feathers. A cogent reason for suspending judgment as to the function of 'stomach stones' is found in their limited distribution. Before asking us to believe that all plesiosaurs had 'gizzard-like arangements' (*sic*), let it be shown that all plesiosaurs and related reptiles had the habit of gorging themselves with foreign matter to the extent asserted of American species, and let no doubt remain that these pebbles are not of adventitious origin.

C. R. Eastman.

Harvard University.

To the Editor of Science: In Science for August 5, 1904, at page 184, mention is made of the stones often found apparently in the stomachs of fossil plesiosaurs, with the suggestion that they may be connected with the food habits of the animals with whose remains they are associated. It is of interest to notice that, according to Mr. Hornaday, the stomachs of the west coast sea lions contain rounded pebbles an inch or two in diameter. As their food seems to be somewhat similar to that of the extinct plesiosaurs, a careful study of the sea lion's habits may be of importance to paleontology.

Julius Henderson.

SPECIAL ARTICLES.

DETERMINATION OF LONGITUDE.

The recent determination of the difference of longitude between San Francisco and Manila by the use of the cables of the Commercial Pacific Cable Company, by the Coast and Geodetic Survey completed the longitude girdle of the earth, and the results will be published in detail in the 'Report of the Superintendent of the Coast and Geodetic Survey,' for 1904. In anticipation of that report the results are now made public by the authority from the superintendent.

The parties in charge of Assistants Edwin Smith and Freemont Morse started for the field in March, 1903, and finally completed the field work in May, 1904. The distance by cable from San Francisco to Manila (7,847 nautical miles) is covered by four cables extending from San Francisco to Honolulu, Honolulu to Midway Island, Midway Island to Guam Island and Guam Island to Manila. For the purpose of exchanging time signals, the Commercial Pacific Cable Company very generously gave the use of the cables to the survey free of charge and at all the stations extended to the

field parties courtesies and assistance without which the execution of the work would have been impracticable. This was specially the case at Guam and Midway Islands, where the parties were almost wholly dependent upon the cable staffs. The transportation to and from these islands is very infrequent and was the cause of the long delay in the completion of the field work.

In the determination of time at the several stations the method set forth in Appendix 7, of the 'Coast and Geodetic Survey Report,' for 1898 was carried out except that it was impossible to observe the same stars at both stations involved in each determination of a difference of longitude, on account of the great difference of longitude and also the unfavorable weather conditions which often necessitated the observation of different stars on consecutive nights. The stars were selected almost exclusively from the list given in the *Berlin Jahrbuch*, and it is believed that the results must be very little if any in error on account of errors of the right ascensions.

The greatest difficulty to be overcome was the eliminations of the difference of personal equation of the observers.

Since 1891, the Germans have used the Repsold registering micrometer on their transits and their experienced observers seem to have almost no personal equation in its use for the determination of time.

In eight differences of longitude determined by them, 1893 to 1903, an exchange of instruments and observers took place midway in the work of each determination, thus giving a determination of the sum of the differences of instrumental and personal equations.

The following results are taken from the *Astronomisch-Geodatische Arbeiten* of the Preussischen Geodatischen Institutes for 1902 and 1904.

		s
	1893	
Ubagsberg-Göttingen	III. Borrass—II. Albrecht	− 0.009
Ubagsberg-Bonn	" "	− 0.019
Bonn-Göttingen	" "	− 0.034
	1898	
Knivsberg-Kopenhagen	III. Albrecht—II. Schumann	− 0.034
Knivsberg-Kiel	" "	− 0.033
	1900	
Potsdam-Burkarest	III. Albrecht—II. Borrass	− 0.017
	1901	
Potsdam-Pulkowa	III. Albrecht—II. Borrass	− 0.025
	1903	
Potsdam-Greenwich	III. Albrecht—II. Wanach	0.000

Had no exchange of place of instruments and observers been made, the errors in the differences of longitude due to personal equation would in no case have been greater than 0.034.

The addition of registering micrometers to the transit of the Coast and Geodetic Survey was considered, but this was found quite impossible in time for the trans-Pacific work.

An exchange of observers took place between San Francisco and Honolulu and difference of personal equation was determined by special observations as often as the observers met. The results are here given. The plus sign means that S observes later than M.

From the exchange of observers between San Francisco and Honolulu, April 20–29 and June 2–13, 1903.

$$S - M = + 0^s.062 \pm 0^s.008.$$

The following are the results from the ten special nights observation:

Locality.	Date.	Stars.		s	s	Wt.
San Francisco	March 28, 1903	20	$S-M=$	+0.085	±0.017	0.7
" "	April 1, 1903	20		+0.092	±0.017	0.7
Honolulu	May 11, 1903	20		+0.109	±0.010	1.0
"	June 27, 1903	20		+0.106	±0 012	0.8
"	April 18, 1904	20		+0.060	±0.009	1.1
"	April 21, 1904	17		+0.079	±0.007	1.4
San Francisco	May 6, 1904	22		+0 075	±0.013	0.8
" "	May 7, 1904	26		+0.045	±0.012	1.0
" "	May 8, 1904	22		+0.043	±0.015	0.8
" "	May 9, 1904	26		+0.087	±0.015	0.8

The mean of the ten nights is:

$$S - M = + 0^s.077 \pm 0^s.005.$$

This result with an assigned weight of 2.0 combined with that determined from the exchange of observers between San Francisco and Honolulu with an assigned weight of 1.3 gives

$$S - M = + 0^s.077 \pm 0^s.007.$$

This personal equation is applied to the differences of longitude between Honolulu-Midway, Midway-Guam, Guam-Manila. The difference of longitude between San Francisco and Honolulu is corrected by the personal equation determined from the exchange of observers only. The range of these results is no greater than should be expected from the computed probable errors and may, therefore, be due to errors of observation rather than to

variation of personal equation. The observers were so placed that personal equation is eliminated in the final longitude of Guam and enters only once in the final longitudes of Midway and Manila. It does not seem that these longitudes can be seriously in error on account of personal equation.

A method of automatically recording time signals over long cables had been successfully used by the Canadian and English observers in the determination of the difference of longitude between Greenwich and Montreal in 1892, but no description of this method was available. A visit was made to the office of the Commercial Cable Co., at New York, where information was obtained which led to the designing and construction at the Coast and Geodetic Survey office, of an apparatus for recording automatically time signals over the cables.

The instrumental outfits of the five stations of the Commercial Pacific Cable Co. are similar. The Muirhead Syphon Recorders are exclusively used, and a description of them can be found in 'Submarine Telegraphs' by Charles Bright. The record is made upon a slip of paper by a syphon pen attached by two fibers to the coil of the recorder. The slip of paper is made to move by an electric motor at the rate of about two centimeters per second. In order that the paper and pen may be adjusted to the proper relation the rollers over which the paper passes are attached to a stand capable of a vertical and two horizontal adjustments. It was necessary that all cable signals should be recorded on this slip of paper at the cable office. The problem was to refer the record of a signal received over the cable to the time as recorded by a break-circuit chronometer. It was solved in the following manner. To the armature of a twenty-ohm Morse relay was attached an arm of aluminum, which carried a syphon pen exactly like the one on the cable receiver. This relay was mounted on a stand capable of a vertical and two horizontal adjustments. This was called the chronometer cable recorder. It could be placed on the table in front of the cable receiver and so adjusted that its syphon pen would record on the slip of paper parallel to the record made by the pen of the cable recorder. The chronometer and battery being put in circuit with the chronometer cable recorder, a record of the chronometer seconds was made on the slip and any signal coming over the cable was recorded by the pen of the cable recorder also on the slip. This cable signal could be brought vertically down to the record of the chronometer and its time read off by the usual scale. On account of the impracticability of always adjusting the pens exactly opposite each other, the cable signal has a correction, the determination of which will presently be explained. Signals were sent by a key such as is used in correspondence over the cable. It is a double key by which a positive or negative current can be sent to the cable. An attachment was made to these keys at the Coast and Geodetic Survey office by which the circuit through the chronometer recorder would be broken the instant the current was put on the cable and thus record the chronometer time of the signal sent. When sending signals the local cable receiver is generally disconnected, but by so arranging a shunt that a small portion of the sending current would pass through the coil of the local receiver a sharp record was also made by the pen of the cable receiver and thus the relation of the two pens was obtained.

At the stations San Francisco, Honolulu and Manila the observatories were so far from the cable office that the chronometer cable recorder at the cable office could not be placed in circuit with the chronometer at the observatory. Another chronometer was, therefore, placed at the cable office to be used in the exchange of the cable signals. At these stations the cable offices and observatories were connected by land lines by which the two chronometers were compared before and after the exchange of cable signals. At Midway and Guam the cable offices and observatories were only a few hundred feet apart, so that the chronometer cable recorder at the cable office could be placed directly in circuit with the chronometer at the observatory and no comparisons of local chronometers was necessary. The results indicate that time signals over long cables can now be exchanged with as great accuracy as over the best land lines.

By the transmission time of a signal over a cable is meant the time that elapses from the instant the record is made on the slip at the sending station to the instant the record is made on the slip at the receiving station. These times as determined from sending signals in both directions over the four cables are given in the last column of the following table. The other data in the table have been kindly furnished by Mr. G. G. Ward, the vice-president and general manager of the cable company.

	Diameter of Copper Conductor.	Length of Cable in Nautical Miles.	Resistance of Copper.	Electromotive Force used.	Transmission Time.
	Inch.		Ohms.	Volts.	s
San Francisco Honolulu	0.1801	2 276 3	5,054	50	0.189
Honolulu-Midway	0.1122	1 332.0	6,530	30	0.118
Midway-Guam	0.1830	2,606.9	4,758	50	0.185
Guam-Manila	0.1183	1,631.6	7,235	35	0.156

The following are the differences of longitude corrected for personal equation as determined over these four cables:

	h	m	s	s
San Francisco-Honolulu	2	21	38.919 ± 0.008	
Honolulu-Midway	1	18	03 219 ± 0.015	
Midway-Guam	2	31	53 584 ±0.010	
Guam-Manila	1	34	43 263 ± 0.010	

The San Francisco station is $8^h\ 9^m\ 48^s.813 \pm 0^s.056$ west of Greenwich (see 'The Longitude Net of the United States and its Connection with that of Europe, 1866–1896,' Appendix 2, Coast and Geodetic Survey Report, 1897, and also 'The Transcontinental Triangulation,' pp. 820 and 826, Coast and Geodetic Survey Special Publication, 1900). The Manila station is $0^s.224$ west of the dome of the Manila Cathedral, which is the accepted point of reference in Manila. Combining these with the above differences of longitude, we have the following longitudes:

	h	m	s	s
Honolulu Transit west of Greenwich	10	21	27.752 ± 0.05	
Midway Transit west of Greenwich	11	49	30.951 ± 0.057	
Guam Transit east of Greenwich	9	38	35.465 ± 0.058	
Manila Cathedral dome east of Greenwich	8	03	52.425 ± 0.059	

Comparisons with former determinations of the longitudes of the several stations.

Honolulu.—In a former issue of this paper* an elaborate discussion of former determinations of the longitude of Honolulu was given by Mr. J. F. Hayford, of the Coast and Geodetic Survey, to which the reader may refer. We will give here only the most reliable one. In 1874 Captain G. L. Tupman, Royal Marine Artillery in charge of the British Transit of Venus Expedition of that year, determined the longitude of his station by seven results from occultations of stars by the moon, fifty-two results from observations of moon culminations and sixty results from the observations of zenith distances of the moon combined with the observed culminations and zenith distances of well-known stars. His result officially communicated to the Hawaiian government is $10^h\ 31^m\ 27^s.2$.

The longitude determined by the Coast and Geodetic Survey by the cables referred to the same point is $10^h\ 31^m\ 27^s.236$, a remarkably close agreement.

Midway Islands.—These islands were discovered by Capt. N. C. Brooks in the *Gambia,* July 5, 1859. In 1867 Capt Reynolds, U.S.N., in the *Lackawana,* visited the islands and gave the longitude of the north point of the larger island as:

Longitude 177° 18′ 20″ west.
h m s
11 49 13.3

In 1900 a survey was made of the islands by the officers of the U. S. S. *Iroquois,* under the command of Lieut. Commander C. F. Pond. The Hydrographic Office Chart No. 1951 is based upon this survey and the longitude given for the point marked Observation Spot is:

Longitude 177° 21′ 30″ west.
h m s
11 49 26 west.

The longitude determined by the Coast and Geodetic Survey by the cables referred to the same point is:

Longitude 177° 22′ 46.″4 west.
h m s
11 49 31.091 west.

Guam Island.—In 1819 M. de Freycinet in the French corvettes *L'Uranie* and *La Physicienne* made a survey of the southern part of the Mariana or Ladrone Islands and gave the longitude of Fort Santa Cruz in the harbor of San Luis D'Apra, Guam Island, as:

* November 6, 1903.

144° 39′ 45″ east.
h m s
9 38 39 east.

(See Findley's 'North Pacific Directory,' p. 800.)

In 1875 the island was visited by Capt. Knorr, of the German Navy, in the ship *Hertha*. The longitude of Fort Santa Cruz was determined to be:

144° 39′ 30″ east.
h m s
9 38 38 east.

See *Annalen Hydrographie,* 1875, p. 284, and also of geographical positions compiled by Lieut. Commander Green and published by the Hydrographic Office, U. S. N., 1883.

In 1899 the officers of the U. S. S. *Yosemite* made a survey of the harbor of San Luis D'Apra. They built a concrete pier on Fort Santa Cruz and determined its longitude by transit observations and the transportation of chronometers back and forth from Yokosuka, Japan. The longitude of this pier as communicated by the hydrographic office is:

Longitude 144° 39′ 21″.45 east.
h m s
9 38 37.43 east.

The longitude determined by the Coast and Geodetic Survey by the cables referred to the same point is:

Longitude 144° 39′ 42″.15 east.
h m s
9 38 38.81 east.

Manila.—Two former telegraphic determinations of the longitude of Manila can be deduced, one *viâ* Madras, India, and the other *viâ* Vladivostock, Siberia.

The longitude of Madras has been determined by five independent series of observations and a résumé of them has been given by Capt. Burrard in Appendix No. 2, Vol. XVII., of the 'Great Trigonometrical Survey of India.' They are as follows:

	h m s	s	
Series *A*	5 20 59.750	± 0.155	1874–5 and 1881-2.
B	5 20 59.010	± 0.163	1874.
C	5 20 59.137	± 0.022	1876, 1881, 1892–4–5.
D	5 20 59.223	± 0.127	1874–7.
E	5 20 59.421	± 0.123	1884–7.

Series *A* is *viâ* Pulkowa, Moscow and through Siberia to Vladivostok by the Russians and thence to Madras by the U. S. Navy. As the series will be used for the deduction of the longitude of Manila direct, it will not be considered in the determination of the longitude of Madras.

Series *B, D* and *E* were mostly determined by the parties who went out to observe the transit of Venus in 1874, and it is stated that the observations were not conducted with the refinement necessary for the determination of fundamental longitudes. It therefore seems at the present that series *C* must be considered the only reliable determination of the longitude of Madras. It is made up of ten differences of longitude in which personal equation was eliminated by the exchange of observers or by special observations. The observers were also so placed that in the final longitude of Madras personal equation would be eliminated. One link in this series is the difference of longitude between Potsdam and Greenwich and this was redetermined in 1903 by the Germans in most refined manner and the result increases the longitude of series *C* by $0^s.098$. This increased result will be used in the deduction of the longitude of Manila.

The difference of longitude between Pulkowa-Greenwich was redetermined by two steps, Pulkowa-Potsdam and Potsdam-Greenwich, by the Germans in 1902–3. This work supersedes the older determinations and will be here used. The difference of longitude Vladivostok-Pulkowa is made up of thirteen differences of longitude by the Russians. In all the work between Vladivostok and Greenwich personal equation was eliminated as in the case of Madras.

In 1881–2 the differences of longitude of Vladivostok-Manila and Manila-Madras was determined by officers of the U. S. Navy. The entire work consists of ten differences of longitude. Seven of them are involved in the difference of longitude Vladivostok-Manila and four in the difference of longitude Manila-Madras. In this work the differences of longitude are not corrected for personal equation and no information as to the value of personal equation of the observers that can now be used can be found. The endeavor was made to so place the observers that personal equation would be eliminated as far as possible in the

resulting longitudes. The difference of longitude Vladivostok-Manila remains uncorrected for plus the difference of personal equation of two of the observers, and the difference of longitude Manila-Madras remains uncorrected for plus twice the difference of personal equation of the same two observers. The two results for the longitude of Manila are as follows:

1.

	h m s	s
Manila Cathedral Dome-Madras, U. S. Navy,	2 42 53.000	± 0.057 + 2 (*N.-G.*)
Madras-Greenwich, English and Germans,	5 20 59.238	± 0.022
Manila Cathedral Dome-Greenwich,	8 03 52.238	± 0.061 + 2 (*N.-G.*)

2.

	h m s	s
Vladivostok-Manila Cathedral Dome, U. S. Navy,	0 43 38.500	± 0.059 + (*N.-G.*)
Vladivostok-Greenwich, Russians and Germans,	8 47 31.197	± 0.146
Manila Cathedral Dome-Greenwich,	8 03 52.697	± 0.157 − (*N.-G.*)

The symbol (*N.-G.*) indicates the unknown personal equation correction to these determinations of the longitude of Manila. Owing to this unknown correction, it is difficult to give proper weights to these two values of the longitude of Manila to combine them with the value recently determined by the Coast and Geodetic Survey *viâ* United States. It is probable that the value of (*N.-G.*) is plus and the corrections, if known, would bring the two longitudes of Manila closer together. Taking the mean of the two values, we have:

	h m s
Manila Cathedral Dome-Greenwich	8 03 52.468 + ½ (*N.-G.*).

which differs only $0^s.042$ or 61.7 feet from the Coast and Geodetic Survey result.

In 1881–2 the U. S. Navy adopted for the longitude of Madras $5^h\ 20^m\ 52^s.42$, which gave for their value of the longitude of Manila $8^h\ 03^m\ 52^s.42$. This value, which differs only $0^s.006$ or 8.8 feet from the Coast and Geodetic Survey result, has been used since 1882.

The difference of longitude San Francisco-Manila determined by the Coast and Geodetic Survey has a probable error of ± 0.022. The longitude of San Francisco depends upon the longitude net of the United States and its connection with that of Europe, and includes seventy-two differences of longitude between forty-five points. Four of these differences of longitude are trans-Atlantic, three by the Coast and Geodetic Survey and one (1892, not yet published) by the English and Canadians. In view of these facts and the unknown correction for personal equation in the other two values of the longitude of Manila, the value determined by the Coast and Geodetic Survey will be accepted.

Edwin Smith.

Coast and Geodetic Survey,
September 2, 1904.

BOTANICAL NOTES.

SYSTEMATIC NOTES.

Two new blackberries (*Rubus vermontensis*, and var. *viridifolius*), allied to *Rubus argutus*, are described by W. H. Blanchard in the July number of the *American Botanist*. They occur in southern Vermont.—The July number of the *Fern Bulletin* contains an annotated list of the ferns of Kentucky by the late Miss S. F. Price. Thirty-eight species of ferns and four lycopods are included.—Professor E. L. Greene continues the publication of his 'Leaflets,' the last fascicle (pages 49–64) bearing date of August 25, 1904, and including systematic discussions pertaining to *Cactaceae*, *Gentianaceae*, *Apocynaceae*, *Cichoriaceae* and *Rhamnaceae*.—In the August number of *Torreya* Dr. N. L. Britton describes a new alder (*Alnus noveboracensis*) from Staten Island.—Mr. C. G. Lloyd's 'Mycological Notes' for June include some interesting paragraphs in regard to the herbaria of Kew, the British Museum, Linnaean Herbarium, Leiden and Berlin, as well as personal notes about some of the botanists now or formerly associated with these collections.—Mr. E. P. Bicknell continues his studies of *Sisyrinchium* in the June *Torrey Bulletin*, describing five new species from California. In the same journal Dr. P. A. Rydberg describes twenty-five new species and varieties of flowering plants from the Rocky Mountain region.—W. A. Murrill continues his series of papers on the *Polyporaceae* of North America in the August *Torrey Bulletin*, and separates the following new genera from *Polyporus*, viz., *Abortiporus*, *Cyclomy-*

cetella, Cycloporus, Globifomes, Nigrofomes and *Poronidulus.*

STUDIES OF SEXUALITY IN BLACK MOLDS.

Every student of botany in the last quarter of a century has given some attention to the black molds (*Mucoraceae*), some species of which are so common as to be obtainable for laboratory use at any season of the year. Yet while every one has been able to study the gross anatomy of black molds, and the formation of their interesting conidia, their zygospores, which are still more interesting, are so difficult to obtain they have rarely been available for study. Whether we regard the sexual organs of black molds as primitively isogamic, or as essentially heterogamic with a degradational approach to isogamy, they are interesting objects of study in the laboratory. Anything which will make it easier to secure these structures is to be regarded as of much importance scientifically and practically. This service has been rendered by Mr. Albert F. Blakeslee in a recent paper published by him in the *Proceedings of the American Academy of Arts and Sciences* (Vol. XL., No. 4, August, 1904), under the title of 'Sexual Reproduction in the Mucorineae.' A preliminary summary of the results of this paper was published in Science, June 3, 1904, and we now have the full account. The present paper contains about 120 pages of text, and is accompanied by four plates aggregating fifty-eight figures. Here are given the details of many experiments undertaken by the author in order to determine the cause or causes of zygospore formation. The ingenuity of some of these experiments must command the admiration of every one who reads the paper. It will be remembered that the most striking result of Mr. Blakeslee's experiments has been the discovery that zygospores of the black molds may be obtained by growing different strains side by side, the zygospores appearing where the hyphae of the two strains intermingle. The practical importance of this discovery will be appreciated by all who have laboratories in which students are at work. The author promises to continue his studies, and reserves an extended discussion of certain problems 'until he has accumulated a greater body of facts on the subject.'

EGG FORMATION IN GREEN FELT (VAUCHERIA).

Dr. Bradley M. Davis has made a careful study of egg-formation (oogenesis) in a species of green felt (*Vaucheria*), one of the common fresh-water algae, and published his results in the August number of the *Botanical Gazette*. These plants have great numbers of minute nuclei which are not separated by walls, and when the lateral protrusion forms in which an egg is finally to develop, it also contains a large number of nuclei. This protrusion (oogone) is soon separated from the rest of the filament by a cross-wall which forms when it is about two thirds its full size. About this time there sets in a degeneration of nuclei resulting in the disappearance of all but one, so that the oogone is eventually uninucleate. The single nucleus increases rapidly in size until 'in the mature egg it is three or four times as large as the original nuclei in young oogonia.'

The author calls attention to the essential agreement of the process of egg formation in *Vaucheria* with those of certain phycomycetetous fungi (*Saprolegnia, Phythium, Peronospora, Plasmopara, Sclerospora, Albugo* and *Araiospora*). He discusses the relationship of *Vaucheria* to other green algae, suggesting its derivation from ancestors whose oogonia were multinucleate. The relationship of the water molds (*Saprolegniales*) and downy mildews (*Peronosporales*) presents some difficulties, but the author calls attention to the fact that they possess many points of similarity to *Vaucheria*. Their relationship to the molds (*Mucorales*) is more obscure, but here again similarities are not wanting. The paper is very suggestive, and will repay careful perusal.

RECENT FORESTRY BULLETINS.

Three bulletins (numbers 47, 48, 49) of much more than ordinary interest have been issued recently by the United States Bureau of Forestry. In the first Professor Bray, of the University of Texas, discusses the 'Forest Resources of Texas.' He calls attention to

the vast area included within the boundaries of Texas, and the great diversity in all the factors (latitude, elevation, soil, rainfall, temperature, sunlight, winds, etc.) which have to do with forest distribution. For example, the rainfall in the eastern part of the state is over fifty inches, diminishing regularly to about ten inches in the extreme west. So too the surface rises from sea-level along the gulf to the high plains 4,000 to 5,000 feet higher, and to mountains which reach an altitude of nearly 10,000 feet. On this diversified surface the forests have been distributed in a most varied pattern. The 'short-leaf pine' occupies a large area two to three counties wide in the northeast, the 'long-leaf pine' a similar area in the southeast, while west of the latter is an area of 'loblolly pine.' In the region west of the Pecos River are small areas of Rocky Mountain conifers. Belts of live oak forests alternate with post oak nearly halfway across the state from southeast to northwest, at last passing into the mesquite and chapparel of central and western Texas. In addition to the forests of the general surface, there are the 'hardwood forests' (composed of oaks, ash, hickory, walnut, gum, elm, cotton wood, linden, maple, osage orange, etc.) of the alluvial bottom lands bordering the streams of the southeast half of the state. A list of sixty 'valuable timber trees' native to Texas is compiled by the author, who adds notes on their distribution, habits and uses.

A second paper by Professor Bray (Bulletin 49) is entitled 'The Timber of the Edwards Plateau of Texas,' and deals with the southernmost province of the Great Plains region where it ends abruptly at the Pecos River and the escarpment line extending easterly from its junction with the Rio Grande. The annual rainfall averages twenty-five inches, being as high as thirty-three inches on its easterly side, and sinking to fifteen inches on the west. The air humidity is usually low, the annual evaporation amounting to more than fifty inches. On this region the forests are slowly spreading, or as the author expresses it, there is 'a transition from grass to woody growth.' The trees which make up the forest areas on the plateau belong chiefly to the Atlantic type, and include elms, live oaks, post oak, walnut, pecan, sycamore, green ash, hickory, soapberry, etc. From the Rocky Mountains have come the pinon pine, two or three cedars and several oaks. The author devotes a considerable space to a discussion of the encroachment of the forests upon the open lands. "Though the encroachment of timber on the prairie is gradual and insidious, to those whose observation covers a space of twenty-five years the change is truly startling. Where at the beginning of that period the prairie held undisputed sway, the observer now finds himself shut in by miles of oak scrub on every side. Men who drove cattle in the early days say that they rode across an open country from above Georgetown to the Colorado breaks, in Williamson County. This same region is now all heavily timbered."

The third paper (Bulletin 48) is on 'The Forests of the Hawaiian Islands,' by W. L. Hall, of the bureau, who made a reconnoisance of the forests of the islands in 1903. The paper opens with the statement that there are two very distinct kinds of forests on the islands, one on the drier lowlands near the sea, and the other on the mountain slopes where there is a heavy rainfall. The first of these consist of the single introduced tree, *Prosopis juliflora*, known as 'algaroba' on the islands. It is the 'mesquite' of Texas and Mexico, and was introduced by Father Bachelot, in 1837. From the original tree, which is still standing, it is now estimated that at least 50,000 acres of forest have sprung, 'fairly well distributed over the different islands.' The native forests, which constitute the type and occur on the mountain slopes, "are distinctively of tropical character. None of the familiar trees of the north temperate zone are present. The observer looks in vain for oaks, maples, pines or spruces." Popular descriptions are given of the more important trees, lehua (*Metrosideros polymorpha*), koa (*Acacia koa*), mamane (*Sophora chrysophylla*) and kukui (*Aleurites triloba*). Attention is called to the decadence of the forests, due to the inroads of cattle, goats, insects and fire and in many places to destructive cutting. The danger of a further reduction of the forest area is

discussed and a far-sighted forest policy is recommended. The setting aside of forest reserves and the exclusion of stock is advocated, as well as the planting of certain areas. The paper is a most valuable contribution to our knowledge of the forests of these islands.

CHARLES E. BESSEY.

DECLARATION OF THE NATIONAL EDUCATIONAL ASSOCIATION.*

1. We can not emphasize too often the educational creed first promulgated more than a century ago that 'religion, morality and knowledge being necessary to good government and the happiness of mankind, schools and the means of education shall forever be encouraged.' This declaration of the fathers must come to us now with newer and more solemn call when we remember that in many parts of our common country the fundamental questions of elementary education—local taxation, consolidation of weak schools, rational supervision, proper recognition of the teacher as an educator in the schools system, school libraries and well trained and well paid teachers—are still largely unsettled questions.

2. We would direct attention, therefore, to the necessity for a supervisor of ability and tact for every town, city, county and state system of public schools. Not only are leaders needed in this position who can appreciate and stimulate the best professional work, but qualities of popular leadership are also demanded to the end that all classes of people may be so aroused that every future citizen of the republic may have the very best opportunities for training in social and civic efficiency.

3. The very nature of the teacher's task demands that that task be entrusted only to men and women of culture and of intellectual and moral force. Inadequate compensation for educational work drives many efficient workers from the school room and prevents many men and women of large ambition for service from entering the profession. It is creditable neither to the profession nor to the general public that teachers of our children, even though they can be secured, should be paid the paltry sum of $300 a year, which is about the average annual salary of teachers throughout the country.

4. The Bureau of Education at Washington should be preserved in its integrity, and the dignity of its position maintained and increased. It should receive at the hands of our lawmakers such recognition and such appropriations as will enable it not only to employ all expert assistance necessary, but also to publish in convenient and usable form the results of investigations; thus making that department of our government such a source of information and advice as will be most helpful to the people in conducting their campaigns of education.

5. We would emphasize the necessity for the development of public high schools wherever they can be supported properly, in order that the largest number possible of those who pass through the elementary grades may have the advantage of broader training, and for the additional reason that the public elementary schools are taught largely by those who have no training beyond that given in the high schools.

6. As long as more than half of our population is rural, the rural school and its problems should receive the solicitous care of the National Educational Association. The republic is vitally concerned in the educational development of every part of its territory. There must be no forgotten masses anywhere in our union of states and territories, nor in any one of its dependencies.

7. We believe that merit and merit alone should determine the employment and retention of teachers, that, after due probation, tenure of office should be permanent during efficiency and good behavior, and that promotions should be based on fitness, experience, professional growth and fidelity to duty. We especially commend the efforts that are being made in many parts of the country whereby teachers, school officials and the general public working together for a common purpose are securing better salaries for teachers and devising a better system for conserving the rights and privileges of all and for improving the efficiency of the schools.

* St. Louis, Mo., July 1, 1904.

8. We declare further that, granted equal character and efficiency, and equally successful experience, women are equally entitled with men to the honors and emoluments of the profession of teaching.

9. We advocate the enactment and rigid enforcement of appropriate laws relating to child labor, such as will protect the mental, moral and physical well-being of the child, and will be conducive to his educational development into American citizenship.

10. The responsibility for the success or failure of the schools rests wholly with the people and therefore the public schools should be kept as near to the people as practicable; to this end we endorse the principle of popular local self-government in all school matters.

11. Since education is a matter of the highest public concern, our public school system should be fully and adequately supported by taxation; and tax laws should be honestly and rigidly enforced both as to assessment and collection.

12. We congratulate and thank the management of the Louisiana Purchase Exposition for giving education first place in the scheme of classification, for the location and grandeur of its building, and for the extent and arrangement of the educational exhibits. Such recognition of education is in harmony with the genius of our democracy and will stimulate interest in popular education throughout the world.

APPEAL FOR COOPERATION IN MAGNETIC AND ALLIED OBSERVATIONS DURING THE TOTAL SOLAR ECLIPSE OF AUGUST 29–30, 1905.

THOSE who are in position to take part in above cooperative work are earnestly requested to make the necessary preparations and to put themselves in communication with the undersigned.

As this will be the best opportunity for some time to come to further test and observe the magnetic and electric phenomena which have been found to occur in connection with total solar eclipses, and as these phenomena are destined to play an important rôle in the theory of the variations of the earth's magnetism and electricity, ascribed to outside forces, it is very much hoped that all countries through which or near which the belt of totality passes will organize and send in the field observing parties.

Owing to the minuteness of the expected magnetic effect, the burden of proof as to its association with the eclipse will largely consist, as in the two previous eclipses, in the connection of the times of the magnetic effects with the times of passage of the shadow cone at the various stations. The observing parties, therefore, should be distributed at intervals along as much of the entire belt as possible.

The above is merely a preliminary notification of the work proposed. Fuller details and suggested directions to be followed will be given later.

L. A. BAUER,
Director.

Address: *Department of Terrestrial Magnetism, The Ontario, Washington, D. C., U. S. A.*

THE COTTON BOLL WEEVIL.

LAST year the chief of the Bureau of Plant Industry prepared, by direction of the secretary, a general plan of work to meet the damage caused by the Mexican cotton boll weevil. With this plan as a basis, the sum of $250,000 was appropriated and became available early in February of this year. The work was divided in the department, part being assigned by the secretary to the Bureau of Plant Industry, and part to the Bureau of Entomology. During the summer the investigations have been pushed forward vigorously by both branches of the department. The department has cooperated with state authorities in locating and taking action upon sporadic outbreaks of the weevil. The farmers in the state of Texas have been thoroughly organized and more than 5,000 have grown cotton under the improved conditions recommended by the department. This work has been in charge of Dr. S. A. Knapp, of the Bureau of Plant Industry, with headquarters at Houston. Extensive work on the improvement of varieties has been inaugurated, the work being conducted by the Bureau of Plant Industry mainly at Terrell, Texas. In order to encour-

age the growing of other crops, diversification farms have been established. This work is being handled by the agrostologist of the department. The results of Mr. O. F. Cook's work in the discovery of the kelep ant have already been announced in these columns. The effects of the general propaganda work in Texas have been good, as many farmers have succeeded in growing good crops of cotton despite the presence of the weevil.

SCIENTIFIC NOTES AND NEWS.

The registration at the International Congress of Arts and Science was as follows:

Foreign speakers	87
Officers and principal American speakers	306
Ten-minute speakers	138
General registration	1,851
Total	2,382

Columbia University has conferred the degree of D.Sc. on Sir William Ramsay, the retiring president, and on Mr. W. H. Nichols, the president-elect of the Society of Chemical Industry.

Professor Hugo de Vries, of the University of Amsterdam, gave an illustrated lecture on 'The Origin of Species, illustrated by the Evening Primrose,' at the New York Botanical Garden, on October 1. On October 3, he was given a farewell reception at the American Museum of Natural History.

At the opening exercises of the one hundred and fifty-first academic year of Columbia University on September 28, Professor Woodward gave the address, taking as his subject 'Academic Ideals.'

It is announced that the first series of the Hertzstein lectures at the University of California will be delivered in October, by Dr. A. E. Taylor, professor of pathology. The lectures have been made possible through the generosity of Dr. M. Hertzstein, of San Francisco, who fully equipped the physiological laboratory and endowed the lectureship for the discussion of special problems in scientific medicine. Professor Taylor's subject will be 'Ferments and Fermentations.'

Major B. F. S. Baden-Powell arrived at New York on the *Campania*, on October 1. He has brought with him kites that he will exhibit at the St. Louis Exposition.

Mr. Thomas H. Kearney, of the Bureau of Plant Industry, U. S. Department of Agriculture, has been authorized to proceed to North Africa and other Mediterranean coast regions for the purpose of securing new seeds and plants adapted to the southwest. A special study will be made of the date and new introductions of this fruit will be undertaken. Alkali-resistant forage crops will also be studied and the introduction of seeds of new and promising kinds will be made. Mr. Kearney will remain abroad until next spring.

The Military-Medical Academy at St. Petersburg has recently installed a portrait of its honorary member, General Kuropatkin, in the main hall as a token of gratitude for his gifts. The academy owes to him the remodeling and enlargement of several of its scientific departments.

The relief expedition, under Mr. W. S. Champ, which has undertaken for the second time to reach the *America,* after going as far as 79° north was driven back by the ice. The *America,* under the command of Mr. Anthony Fiala, has not been heard from for a year, but there is said to be no anxiety concerning it.

Professor Robert Koch has been presented with a portrait bust and a Festschrift on the occasion of his sixtieth birthday.

The funeral of Professor Niels Finsen, the discoverer of the light cure for lupus, took place on September 27. The Kings of Denmark and Greece were present, and there were special representatives from Emperor William, King Edward and other rulers.

Mr. Arthur D. Wyman, assistant in chemistry at Harvard University, was killed by an automobile on September 28.

Mr. B. M. Everhart, the botanist, died at West Chester, Pa., on September 22, at the age of eighty-seven years.

Those having reprints of the late Dr. Greeley's paper on 'The effect of variations in the temperature upon the process of artificial parthenogenesis' (published in the *Biological*

Bulletin, February, 1903), which they are willing to dispose of are requested by Professor Starbird, Washington University, St. Louis, Mo., to communicate with him.

An additional appropriation of $75,000 for the continuation of construction work at the New York Botanical Garden, voted by the Board of Estimate and Apportionment on June 24, 1904, became available by the signature of His Honor Mayor McClellan, on August 9, 1904. It is expected that the expenditure of this money will complete all the driveway bridges and their approaches, and all, or nearly all, of the driveways laid down in the general plan of the garden, approved by the board of managers and by the department of parks on June 21, 1897.

The daily papers state that Mr. Archer M. Huntington has had incorporated the Hispanic Society of America, and has made to the trustees a gift of $1,000,000. The gift consists of a building to be erected in Audubon Park, New York, which will cover about eight city lots, a suitable endowment, and an extremely valuable collection of Spanish books, paintings, manuscripts and objects of archeological interest now in the Huntington library at 'The Pleasance,' Bay Chester.

The Austrian Meteorological Society has received from the Emperor of Austria the right to use the letters 'K.K.,' equivalent to Royal Imperial, before its name, so that its official designation now becomes the 'k.k.Oesterreichische Gesellschaft für Meteorologie.'

The International Pure Food Congress held its session at St. Louis last week.

The fifteenth annual general meeting of the British Institution of Mining Engineers was held at Birmingham beginning on September 14. There was a good attendance of members from various parts of the kingdom, and in addition there were present between 50 and 60 visitors from the Association des Ingénieurs Sortis de l'Ecole de Liége. The Secretary, Mr. M. Walton Brown, submitted the annual report of the council, which stated that since the formation of the institution in 1889 the membership had increased from 1,239 to 2,704. The secretary announced that Sir Lowthian Bell had been elected president for the ensuing year.

A correspondent writes to the London *Times* that the second International Philosophical Congress was held at the University of Geneva from September 4 to 8, and was attended by 500 members, representative of every school of philosophic thought in Europe. The congress was presided over by the venerable Swiss philosopher, M. Ernest Naville. At the inauguration of the congress Professor Gourd, of the Faculty of Philosophy at the Geneva University, referred to the excellent results of the first congress held in Paris, in 1900, from the point of view of the teaching of philosophy, and of obtaining additional information of the nature and value of the divers philosophical works of our age. Professor Boutroux, of l'Institut Paris, read a paper on 'The Rôle of the History of Philosophy in the Study of Philosophy.' Professor Stein (of the University of Berne, and Gourd (of the University of Geneva) dealt with 'The Definition of Philosophy'; Professor Windelband (of Heidelberg) with 'The Present Task of Logic and Philosophical Inquiry in Relation to Natural Science and Culture'; Professors Vifredo Pareto (of Lausanne) and De Greef (of Brussels) with 'The Individual and Society'; and Professor Reinke (of Kiel) and Giard (of Paris) with 'Neovitalism and Finality in Biology.' At the sectional meetings the subjects under discussion were 'The History of Philosophy,' 'General Philosophy and Psychology,' 'Applied Philosophy,' 'Logic and Philosophy of the Sciences' and 'History of the Sciences.'

The Ben Nevis Observatories will be closed. Mr. R. T. Ormond, the honorary secretary, explains that two years ago the directors stated that they could not continue to carry on the observatories any longer under existing conditions. The meteorological council at the same time resolved to withdraw £250 of the £350 given by them. But the appointment of a committee of inquiry into the administration of the parliamentary grant for meteorology led to an effort being made to continue the work at the observatories until the committee had reported. The meteorological council

therefore continued their grants of £350 for two years, and the directors obtained from a gentleman interested in the work sufficient funds to carry on the observatories, in the same manner as hitherto, till October of this year. The committee issued their report a few months ago, but as in it they only recommended a continuance of the old grant of £350, the directors sent a letter to the First Lord of the Treasury asking for an additional grant of £600 to defray that part of the annual expenditure which has up to this time been met by subscriptions. In reply the treasury refused an additional grant, but offered to pay the £350 recommended by the Committee of Inquiry direct to the Scottish Meteorological Society on behalf of the Ben Nevis Observatory, instead of making this sum a charge on the meteorological grant. The continuance of the observatories could only be undertaken on a guaranteed income of £1,000 a year. The Treasury has only offered £350 a year, and the directors have therefore no choice but to close the observatories.

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A Welsh national conference of delegates appointed by the Welsh county councils to discuss the questions of afforestation in the principality met recently at Swansea, Sir Charles Philipps, the chairman, says the London *Times,* in referring to the great importance of the study of forestry, said that the object of that meeting was to consider how best to advise the county councils. After reference to the report of the departmental committee of 1902, the speaker said that there was in Wales an enormous area which could be profitably afforested, and pointed to the fact that afforestation gave employment to ten men, where sheep farming would only give employment to one. It was necessary that professors of the subject should be appointed at the universities and that practical demonstration areas should be set apart. One of the latter had been already established on high meadow-land in the Forest of Dean. The view was expressed, in course of discussion, that the establishment of a central school of forestry for Wales was of the utmost importance, and that such a school would become self-supporting after a few years. It was at length resolved that the members should urge on their respective councils the great importance of the study and practical application of forestry by providing lectures to be given at suitable centers and bursaries, enabling students to attend these lectures; also that a central school of forestry be established with example plants of three or more acres, and demonstration areas of suitable extent, and that the necessary expense be defrayed by the county councils on the basis of their respective ratable values, the whole amount now asked for not to exceed £5,000. It was further resolved to communicate what was being done to the government department, in the hope that a grant from the state would be made towards their efforts.

It is stated in the *Bulletin of the American Geographical Society* that Mr. Shimpei Kamase has presented to the society's library an excellent photograph of his relief map of the Japanese Empire, which is attracting much attention in the Transportation Building at the St. Louis Exposition. This map, about 100 feet in length by 50 in width, is so large that clear idea of relief features is given without very great exaggeration of the vertical scale. The exaggeration is threefold—sufficient, of course, to distort in some measure the mountain features, but it does not give the observer the grossly-erroneous impression of the topography that is conveyed by not a few

relief models where the vertical is five to eight times as large as the horizontal scale. The map, made at Fukuoka, the home of its designer, is based upon the general staff map, and the results of the topographic surveys have been carefully reproduced in this miniature representation of the mountains, valleys, plains and seas of the island empire. Every place of any importance is indicated; and the map gives a vivid idea of the remarkable development of Japan in postal, railroad, telegraph and steamship enterprises.

THE quarterly return of births, deaths and marriages for England and Wales has been published by authority of the registrar-general. The population of the United Kingdom in the middle of 1904 is estimated at 42,786,466 persons; that of England and Wales at 33,763,434, that of Scotland at 4,627,656 and that of Ireland at 4,395,376. In the United Kingdom 300,358 births and 164,534 deaths were registered in the three months ended June 30, 1904. The total increase of population was, therefore, 136,424. The number of persons married in the quarter ended March 31, 1904, was 118,968. The birth-rate in the United Kingdom in the second quarter of 1904 was 28.2, and the death-rate 15.4 per 1,000. The marriage-rate in the first quarter of 1904 was 11.2 per 1,000. According to the returns issued by the Board of Trade, it appears that 118,830 emigrants embarked, during last quarter, from the several ports of the United Kingdom at which emigration officers are stationed, for places outside Europe. Distributing proportionally 1,158 emigrants whose nationality was not ascertained, the emigrants that were natives of the United Kingdom numbered 76,294, of whom 47,054 were English, 11,648 Scottish and 17,592 Irish, while 42,536 others were of foreign nationality. The proportions of emigrants accredited to the several parts of the United Kingdom, per million of the respective estimated populations, were as follows: England, 1,394; Scotland, 2,517; and Ireland, 4,002. Compared with the averages in the three preceding second quarters, the proportion of English emigrants showed an increase of 27.2 per cent., that of Scottish emigrants an increase of 46.3 per cent., and that of Irish emigrants a decrease of 1.4 per cent.

ACCORDING to the *Scottish Geographical Journal* some interesting notes on the researches of Dr. David, a naturalist apparently of Swiss nationality, in the Congo forest and the western flanks of the Ruwenzori range, are given in a recent number of *Globus* (vol. 86, No. 4). The traveler has distinguished himself by being the first European to secure a specimen of the okapi with his own gun, which will permit for the first time an accurate knowledge of the physical characters and general bearing of the animal. According to Dr. David, the specimens which have been set up in this country and Belgium have been incorrectly treated, which, all things considered, is not surprising. The okapi, although a ruminant, has all the bearings of a tapir, not at all that of an antelope. The markings are much finer than those of the zebra, the stripes being black within white, and almost all double. The back is reddish, especially in the male, the ears enormously long, the mane erect. Some specimens of both sexes possess horns, while others are entirely without, and Dr. David is on this account inclined to distinguish two species. The animal stands from 4 to 5 feet high at the withers. Another find which is interesting from a zoological point of view is that of an armadillo 4 feet long, closely resembling its congener of the pampas. It frequently assumes an erect attitude, supporting itself on its tail and holding the tree-trunks with its powerful fore claws. Dr. David has also ascended the western slopes of the Ruwenzori range to a height which he estimates at 16,700 feet, which, if correct, would be the greatest altitude yet attained. His routes seem to have led somewhat to the north of Dr. Stuhlmann's. The range, he says, is composed of a series of ridges of granite, diorite and diabase, no traces of basalt or porphyry being seen. The snow-level occurs at about 14,500 feet, but glacier-tongues reach down to about 13,000. Two small moraine-lakes were seen, and a little below them was a third lake of milky-green color, surrounded by thick vegetation; while a fourth, which was fed by glacier streams, was clear, though of a

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greenish-brown color, perhaps derived from the neighboring moorland. Like other visitors to the range, Dr. David attempts to define the zones of vegetation met with, of which he distinguishes six or seven, though the uppermost four, above the zone of bamboos, all form moorland of one sort or another. The *Senecio Johnstoni* was found up to 12,800 feet. There was a striking absence of flowers, and of the lush dwarf vegetation characteristic of the Alps. Trees ascend higher on the wall-like sides and slopes of the mountains than on the crests and ridges, but no distinction could be traced between slopes exposed to wind, rain or sun, and the reverse. The vegetation observed on the glacier-tongues on which 3 feet of new snow was lying was of interest, the *Senecio Johnstoni* growing with its base almost in the ice, and its roots embedded in the ground-moraine, which was frozen at the surface, though of a higher temperature below. Dr. David hopes to continue his researches in this region.

UNIVERSITY AND EDUCATIONAL NEWS.

The daily papers state that about $300,000 is left to public institutions by Mrs. Elizabeth Green Kelly, including $100,000 to the University of Chicago.

The increased appropriations for Miami University by the legislature of the state of Ohio at its last session have rendered it possible to enlarge the Science Hall, given by Senator Brice, '63, to about three times its present capacity. The new Brice Hall will be occupied by the departments of chemistry, physics and biology of the Liberal Arts College and by the natural history department of the State Normal School. The $40,000 dormitory for women, also authorized by the legislature, is in process of construction.

The will of Mrs. Sarah B. Potter, of Boston, contains public bequests aggregating over $1,000,000, including $150,000 to the Boston Medical Library, $100,000 to the Kindergarten for the Blind, at Jamaica Plains, and $50,000 to Harvard University.

A new building, to cost $100,000, is to be built on the campus of the University of Southern California at Los Angeles. It will be devoted to the science departments.

G. C. Fracker, A.M. (Iowa), professor of psychology at Coe College, has been granted leave of absence to take the assistantship in psychology at Columbia University, vacant by the call of Mr. Henry A. Ruger to the chair of psychology at Colorado College. Mr. Frank G. Bruner, assistant in psychology at Columbia University, has been given leave of absence until the close of the Louisiana Purchase Exposition, where in the absence of Dr. R. S. Woodworth, instructor in psychology, he has charge of the Anthropometric and Psychometric Laboratories. Mr. F. L. Wells, A.B. (Columbia), has been appointed acting assistant for this period.

The following appointments have been made in the Albany Medical College: Dr. Richard Mills Pearce has succeeded Dr. George Blumer as professor of bacteriology and pathology; Dr. Spencer L. Dawes, adjunct professor of materia medica; Dr. Wilfred S. Hale, demonstrator of anatomy and assistant curator of the museum; Dr. Edwin McD. Stanton, lecturer on histology; Dr. Howard E. Lomax, instructor in anatomy; Dr. Charles K. Winne, Jr., instructor in bacteriology; Dr. George G. Lempe, instructor in anatomy; Dr. Donald Boyd, demonstrator in anatomy of the nervous system; Dr. Edward F. Sibley, instructor in clinical microscopy, and Dr. Silas L. Filkins, prosector of anatomy.

According to the London *Times* Mr. Ernest Shearer, M.A., B.Sc., Kirkwall, has been appointed lecturer on agriculture at the Pusa Imperial College, Bengal. This agricultural college for all India, with a farm of 1,300 acres attached, is one of the developments resulting from the appointment two or three years ago of another Scotsman, Mr. James Mollison, as inspector-general of agriculture in India. Mr. Alexander Sangster, Montrose, has been appointed junior assistant with the Abukir Land Reclamation Company, near Alexandria, Egypt, and Mr. John C. Leslie, B.Sc., has been appointed assistant conservator of Forests in Southern Nigeria.